

WHAT IS CLAIMED IS:

1 1. A method of forming an optical waveguide on an undercladding
2 layer of a substrate, the method comprising:
3 forming at least one silicate glass optical core on said undercladding
4 layer using a high-density plasma deposition process including a silicon source gas and
5 an oxygen source gas;
6 wherein the refractive index of the undercladding layer is less than the
7 refractive index of the optical core.

1 2. The method of claim 1 wherein the high-density plasma process
2 comprises pressure of less than 100 millitorr and an RF energy greater than 3
3 Watts/cm².

1 3. The method of claim 2 wherein the high-density plasma process
2 further comprises a nitrogen source gas and the optical core comprises silicon, oxygen,
3 and nitrogen.

1 4. The method of claim 3 wherein the nitrogen source gas is
2 molecular nitrogen.

1 5. The method of claim 3 wherein the optical core is an SiON
2 optical core.

1 6. The method of claim 3 wherein the ratio of oxygen atoms to
2 silicon atoms is greater than 3:1.

1 7. The method of claim 3 wherein the silicon source comprises
2 silane, the oxygen source comprises molecular oxygen, and the nitrogen source
3 comprises molecular nitrogen.

1 8. The method of claim 7 wherein the ratio of molecular oxygen to
2 silane is greater than 1.5:1.

1 9. The method of claim 7 wherein the oxygen source flow is
2 between 200-600 sccm.

1 10. The method of claim 7 wherein the ratio of molecular nitrogen to
2 silane is between 0.5 and 5.0.

1 11. The method of claim 7 wherein the nitrogen source flow is
2 between 300-500 sccm.

1 12. The method of claim 1 wherein the high-density plasma process
2 is carried out at a temperature of greater than 600°C.

1 13. The method of claim 1 wherein the optical core comprises a
2 phosphorus doped silicate glass or germanium doped silicate glass.

1 14. The method of claim 1 wherein the contrast between the
2 refractive index of the core and the refractive index of the undercladding layer is
3 greater than 2%.

1 15. The method of claim 1 wherein forming at least one optical core
2 comprises:
3 depositing a continuous optical core layer using said high-density
4 plasma deposition process; and
5 etching the continuous optical core layer to form the at least one optical
6 core.

1 16. The method of claim 15 wherein the depositing using said high-
2 density plasma deposition process does not use an RF bias.

1 17. The method of claim 1 wherein forming at least one optical core
2 comprises:
3 etching at least one trench in the undercladding layer;
4 depositing the at least one optical core in the corresponding at least one
5 trench using said high-density plasma deposition process; and
6 depositing an uppercladding layer over the at least one optical core.

1 18. The method of claim 17 wherein the depositing using said high-
2 density plasma deposition process does includes an RF bias.

1 19. The method of claim 1 wherein said high-density plasma
2 deposition process is a high-density plasma electron-cyclotron resonance process.

1 20. The method of claim 1 wherein said high-density plasma
2 deposition process is a high-density plasma chemical vapor deposition process.

1 21. The method of claim 1 further comprising annealing the at least
2 one optical core after the high-density plasma deposition process.

1 22. A method of depositing an optical core on a substrate in a
2 processing chamber comprising:
3 establishing a pressure of less than 100 millitorr in said processing
4 chamber;
5 generating an RF power density of greater than 3 Watts/cm²; and
6 providing a silicon source gas, an oxygen source gas, and a dopant
7 source gas in said processing chamber, wherein the dopant source gas increases the
8 refractive index of said optical core above 1.46.

1 23. The method of claim 22 wherein the ratio of oxygen atoms to
2 silicon atoms is greater than 3:1.

1 24. The method of claim 22 wherein the dopant source gas is a
2 nitrogen source gas and the optical core comprises silicon, oxygen, and nitrogen.

1 25. The method of claim 24 wherein said nitrogen source gas is
2 molecular nitrogen.

1 26. The method of claim 25 wherein the silicon source gas is silane.

1 27. The method of claim 26 wherein the ratio of molecular nitrogen
2 to silane is between 0.5 and 5.0.

1 28. The method of claim 22 wherein the dopant source gas is a
2 phosphorus containing gas or germanium containing gas.

1 29. A substrate processing system comprising:
2 a housing defining a process chamber;

3 a high-density plasma generating system operatively coupled to the
4 process chamber;
5 a substrate holder configured to hold a substrate during substrate
6 processing;
7 a gas-delivery system configured to introduce gases into the process
8 chamber, including sources for a silicon-containing gas, an oxygen-containing gas, and
9 a dopant-containing gas;
10 a pressure-control system for maintaining a selected pressure within the
11 process chamber;
12 a controller for controlling the high-density plasma generating system,
13 the gas-delivery system, and the pressure-control system; and
14 a memory coupled to the controller, the memory comprising a computer-
15 readable medium having a computer-readable program embodied therein for directing
16 operation of the substrate processing system to form an optical core a substrate, the
17 computer-readable program including
18 instructions to flow a gaseous mixture containing flows of the
19 silicon-containing gas, the oxygen-containing gas, and the dopant-containing gas;
20 instructions to maintain a pressure of less than 100 millitorr
21 within the process chamber; and
22 instructions to provide an RF power density greater than 3 Watts/
23 cm² into the process chamber, and in accordance therewith, generate a high-density
24 plasma from the gaseous mixture and deposit a doped silicate glass optical core,
25 wherein the dopant-containing gas increases the refractive index of said optical core
26 above 1.46.

1 30. The substrate processing system of claim 29 wherein the ratio of
2 oxygen atoms to silicon atoms is greater than 3:1.

1 31. The substrate processing system of claim 29 wherein the dopant-
2 containing gas comprises a nitrogen-containing gas and the optical core comprises
3 silicon, oxygen, and nitrogen.

1 32. The substrate processing system of claim 31 wherein the silicon-
2 containing comprises silane and the nitrogen-containing gas includes molecular
3 nitrogen.

1 33. The substrate processing system of claim 32 wherein the ratio of
2 molecular nitrogen to silane is between 0.5 and 5.0.

1 34. The substrate processing system of claim 29 wherein the
2 substrate holder comprises an electrostatic chuck, and wherein computer-readable
3 program further includes instructions for turning electrostatic chuck off during
4 deposition of the silicate glass optical core.

1 35. The substrate processing system of claim 29 further comprising a
2 top RF source and a side RF source, wherein the ratio of power of the top RF source to
3 the side RF source is between 0.21 and 0.73.

1 36. The substrate processing system of claim 29 wherein the dopant
2 containing gas is a phosphorus containing gas or germanium containing gas.

1 37. A computer-readable storage medium having a computer-
2 readable program embodied therein for directing operation of a substrate processing
3 system including a process chamber; a plasma generation system; and a gas delivery
4 system configured to introduce gases into the process chamber, the computer-readable
5 program including instructions for operating the substrate processing system to form an
6 optical core on a substrate disposed in the processing chamber in accordance with the
7 following:

8 establishing a pressure of less than 100 millitorr in said processing
9 chamber;

10 generating an RF power density of greater than 3 Watts/cm²; and

11 providing a silicon source gas, an oxygen source gas, and a dopant
12 source gas in said processing chamber, wherein the dopant source gas increases the
13 refractive index of said optical core above 1.46.

1 38. The computer-readable storage medium of claim 37 wherein the
2 ratio of oxygen atoms to silicon atoms is greater than 3:1.

1 39. The computer-readable storage medium of claim 37 wherein the
2 dopant source gas is a nitrogen source gas and the optical core comprises silicon,
3 oxygen, and nitrogen.

1 40. The computer-readable storage medium of claim 39 wherein said
2 nitrogen source gas is molecular nitrogen and the silicon source is silane.

1 41. The computer-readable storage medium of claim 40 wherein the
2 ratio of molecular nitrogen to silane is between 0.5 and 5.0.

1 42. The computer-readable storage medium of claim 37 wherein the
2 dopant source gas is a phosphorus containing gas or germanium containing gas.

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